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I. C. 6378

NOVEMBER, 1930

DEPARTMENT OF COMMERCE

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H. TOMLINSON

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SHAFT SINKING AT THE SEVIER VALLEY COAL CO. MINE[1]

By H. Tomlinson[2]

INTRODUCTION

The development of the Sevier Valley Coal Co.'s mine marks the opening of the Salina Canyon coal district in Utah. The mine is favorably located with respect to the existing markets of the West, and if the present estimates of the amount of workable coal in it are accurate it has many important advantages in favor of its development.

This mine is situated 18 miles east of the town of Salina, Sevier County, Utah, which at present is the nearest shipping point on the Marysvale branch of the Denver & Rio Grande Western Railroad, and is about 152 miles south of Salt Lake City, which is the distributing center for much of the coal from the Carbon - Emery coal field and is the place from which nearly all Utah coal shipped to San Francisco and points on the northern Pacific coast has a common haul.

In addition to these markets, an important market for coal from the Salina Canyon district is near at hand in the Sevier and Sanpete Valleys, which consume approximately 150,000 tons of coal annually for domestic, sugar-beet factory, and cannery fuel. This district has an advantage in freight rates varying from 30 cents to $1.30 over the Carbon-Emery district, which at present supplies this demand.

In this paper a description is given of the method of sinking and lining the shaft, which is 182 feet below ground level, 17 feet wide, and 25 feet long, finished into three compartments (two of which are 7 by 12.5 feet to be used for hoisting, and one 4 by 12.5 feet to be used for a stairway and for pump and power lines), and lined from top to bottom with reinforced concrete.

ACKNOWLEDGMENT

The writer wishes to acknowledge the cooperation of Mr. H. E. Lewis, vice president and general manager of the Sevier Valley Coal Co., in furnishing the data which made this paper possible.

1 - The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6378."

2 - Mining engineer, mining division, U. S. Bureau of Mines.

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HISTORY

Work on sinking the shaft was commenced in 1924 and completed in 1926. Due to the fact that the railroad was not completed to the property, and to the difficulty encountered because of the lack of a road over which equipment and materials may be hauled, further developments were abandoned until 1930, when the railroad was completed.

GENERAL INFORMATION

Geological Measures

The geologic formations exposed in the Salina Canyon district range from the upper Cretaceous Black Hawk formation and the middle formation of the Mesaverde group of the Wasatch Plateau to the upper part of the Eocene Wasatch formation. The coal beds occur in the Black Hawk formation of the Cretaceous period; the exposed part of the formation consists of about 550 feet of buff, gray, and brown sandstone, gray shale and several thin coal beds, a rock succession similar in general to the type common in the coal-bearing parts of the Mesaverde formation throughout the Book Cliffs and Wasatch Plateau coal districts of Carbon and Emery Counties, Utah.

Method of Prospecting

The method of prospecting employed to prove the character, quality, thickness, and dip of the coal bed to be mined consisted of a series of diamond-drill holes placed at various points on the property. The findings of these diamond-drill holes were verified by sinking the shaft, and by a shaft sunk by another company adjoining this property. A typical section of the measures above and of the coal bed to be mined is shown in Figure 2.

Coal Beds

The coal beds of the Salina Canyon district dip about 1.7 per cent to the Southwest and are similar in almost all characteristics to those of the other parts of the Wasatch Plateau coal field. They are bituminous in rank and of good quality almost throughout. They are black, hard, and lustrous. Coal from both beds contains resin in thin lenses on the parting planes. The upper or thin bed, termed Resin coal, contains an unusual amount of resin.

Resin Coal Bed

The Resin coal bed lies 195 feet above the lower bed. It averages about 30 inches in thickness over the property, and crops out about 13 feet above the collar of the shaft. This bed was opened for the purpose of furnishing coal to generate steam while sinking the shaft to the lower coal bed.

Lower Coal Bed

The shaft was sunk for the purpose of placing coal from the lower bed on the market. It is locally called the Castle Gate bed, and has similar characteristics to the Castle Gate "A" bed, which is mined in Carbon County, and the

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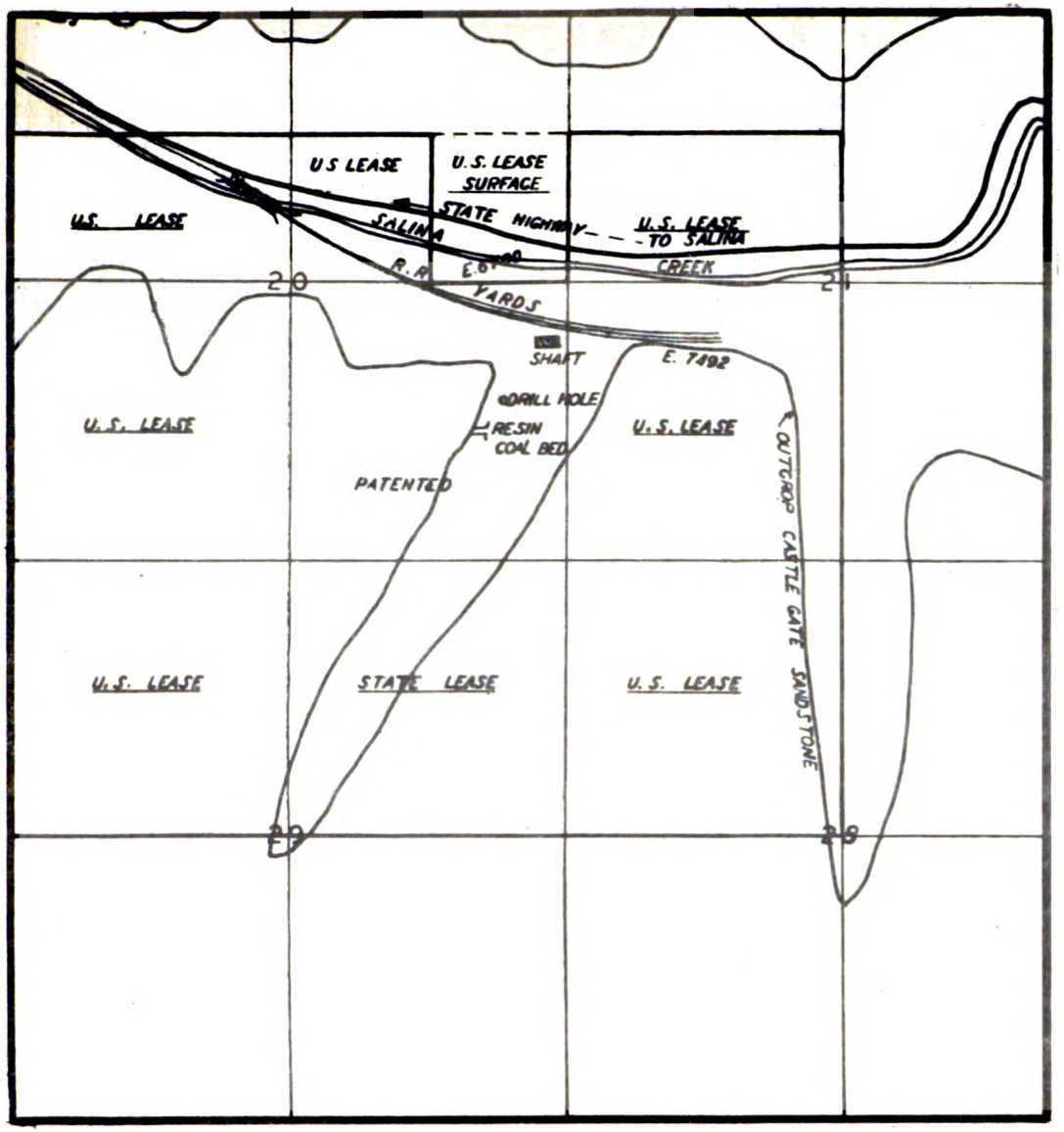

Figure 1.- Property map of Sevier Valley Coal Co.

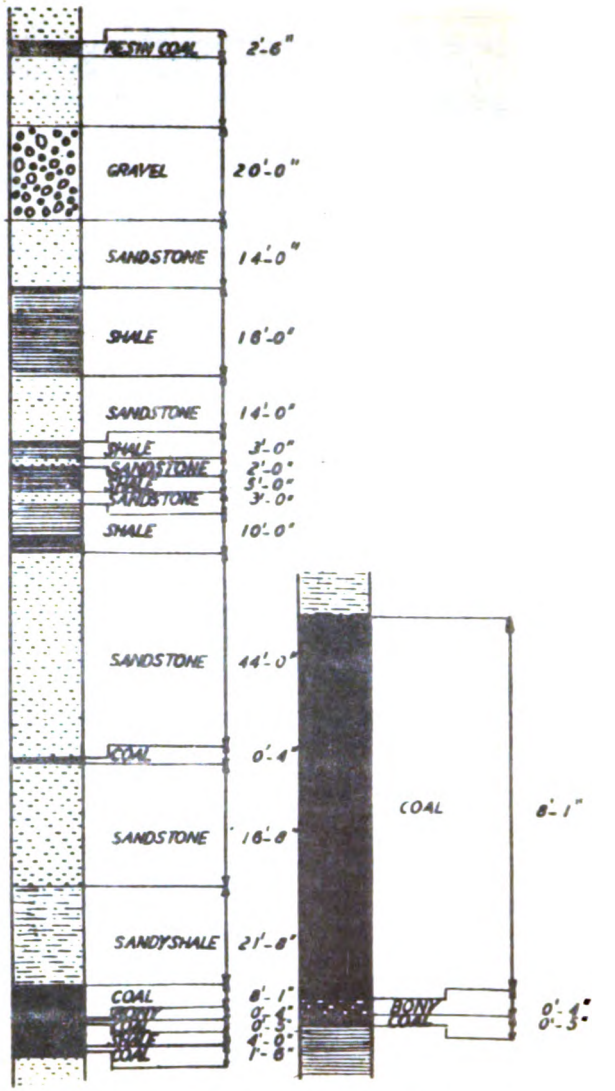

Figure 2.- Typical section of geological measures and coal bed

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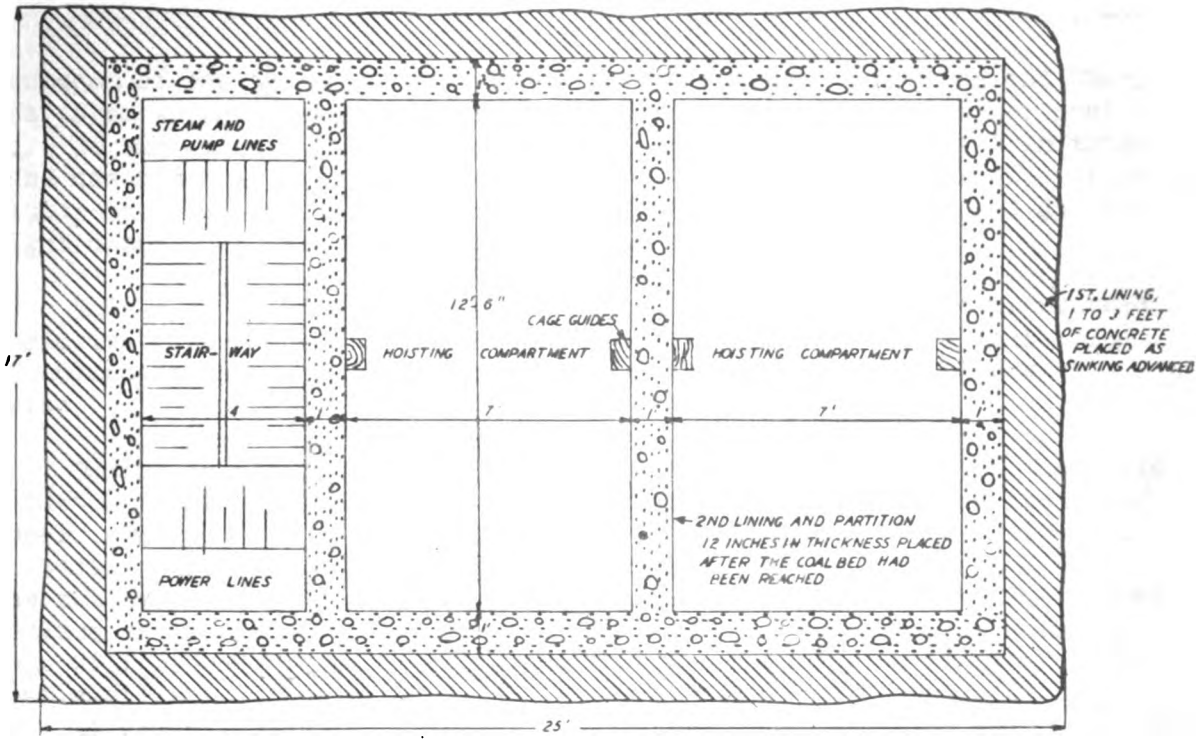
STEAM AND PUMP LINES
STAIR- WAY
POWER LINES
12' 6"
CAGE GUIDES
HOISTING COMPARTMENT
HOISTING COMPARTMENT
1ST. LINING, 1 TO 3 FEET OF CONCRETE PLACED AS SINKING ADVANCED
2ND LINING AND PARTITION 12 INCHES IN THICKNESS PLACED AFTER THE COAL BED HAD BEEN REACHED
17'
25'

Figure 3.- Plan of completed shaft

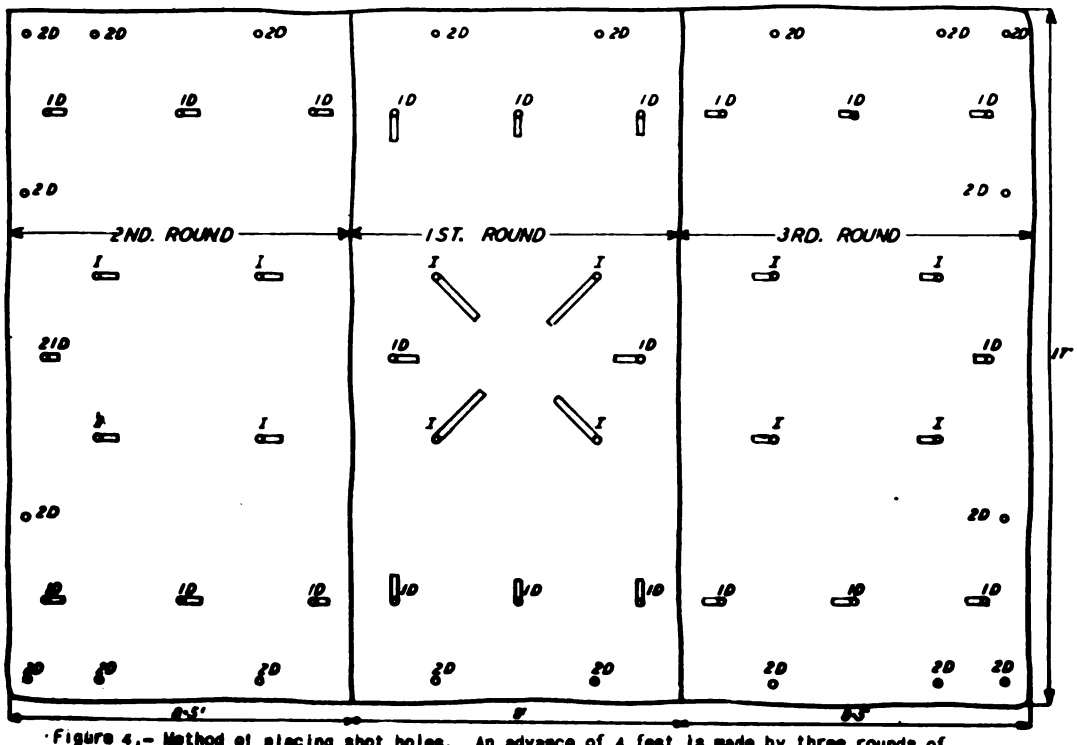

Figure 4.- Method of placing shot holes. An advance of 4 feet is made by three rounds of shots placed as illustrated. Shot holes 4 5/8 inches in diameter are drilled by air-driven jackhammers to a depth of 5 feet. Two sticks of explosive 8 by 1 1/4 inches in dimensions and 40 per cent strength are used in each hole, exploded by detonators of various speeds at 3-second intervals indicated by the symbols, I, instaneous, 1D, first delay, and 2D, second delay, fired electrically from the surface

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lower subseam of the Spring Canyon series, which is mined in Carbon and Emery Counties, from which a greater tonnage is produced than from any other coal bed in Utah. It varies on this property from 8 feet 4 inches to 11 feet in thickness, and has a bed of bony 4 inches thick about 8 feet from the roof. It is a black lustrous coal, and is favorably received on the domestic market due to its bright appearance after being shipped long distances.

This coal is massive and free from shaly impurities. So pronounced is the massive nature where the coal is fresh that seams or lines indicating stratification are scarcely discernible. It mines in irregular blocks of large size.

During development work the practice has been to shoot off the solid with a fast explosive, which has a tendency to produce an excessive amount of small coal. The product is passed over a screen consisting of bars placed 3 inches apart. Under these unfavorable blasting conditions the minus 3-inch size has not exceeded 20 per cent. Should this physical condition of the coal bed continue as development work and ability to produce progresses, a decided advantage will be enjoyed at this operation when consideration is given to the fact that realization from minus-3-inch sizes is invariably below cost of production. At several operations in the Carbon-Emery coal district which will be the chief competitors of the Sevier Valley mine, the minus-3-inch sizes generally run between 46 and 48 per cent of the total production. The 1-5/8 by 3 inch nut averages about 14 per cent, while the minus 1-5/8-inch sizes average about 32 to 34 per cent.

A typical analysis of the lower coal bed is as follows:

Fixed carbon	49.3
Volatile matter	39.5
Moisture	5.0
Ash	6.2
	100.00
B. T. U.'s, Haas formula	14102

Openings

Following the precedent of the large shaft operations of Illinois, which affords economical operation and avoids duplication of underground facilities on the surface, it was decided by the management to sink a rectangular shaft 17 by 25 feet in dimensions and 182 feet deep divided into three compartments, two of which are 7 by 12.5 feet, to be used for hoisting the product, men, and materials, and one 4 by 12.5 in which is installed a stairway and the pump and power lines (fig. 3).

At a later date a rock slope 7 by 12 feet and approximately 600 feet long, dipping on a 30 per cent grade across the measures to intercept the coal bed, will be driven to serve as air and manways.

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METHOD OF SINKING

Shaft

Sinking was commenced in 1924 and was carried on intermittently until completed in 1926. The actual sinking operations were completed in 182 8-hour shifts, an average of 1 foot per 8-hour shift. These shifts, however, were not consecutive, as there was considerable delay due to placing the first concrete lining 1 to 3 feet in thickness so as to avoid the use of expensive timber for support, and to keep the water under control.

The sinking was kept in line and vertical by using four suspended plumb bobs, steadied by water, and was excavated in three sections. The first section, 8 by 17 feet, was first taken in the center, thus allowing the water to drain to the center and enabling the muck car and weights holding the guide ropes to rest in the lowest part of the excavation for the major part of the time. After the excavation had been made in the center to a depth of 4 feet, then the section on either side was taken, as shown in Figure 5. This method of procedure was continued until the coal bed was reached at a depth of 182 feet.

Sinking was carried on during two 8-hour shifts, the third shift being used to make repairs and other necessary work. The following men were employed on each shift.

In the shaft:

Drillers	1
Muckers	3

Outside:

Hoisting engineer	1
Fireman on boilers	1
Shift boss in charge of shift	1
Total	7

In addition to the above employees a superintendent and a master mechanic were in charge of the three shifts. All employees were paid on a day-wage basis. Eight hours constituted a day's work.

The following tables show the shifts employed, man-hours, and cost per foot of sinking.

Shifts employed, man-hours, and cost per foot of sinking

	Shifts	Man-hours	Depth of shaft	Man-hours per foot of advance
Drillers	182	1,456	182	8
Muckers	546	4,368	182	24
Hoist engineer	182	1,456	182	8
Fireman	182	1,456	182	8
Shift boss	182	1,456	182	8
Total	1,274	10,192	182	56

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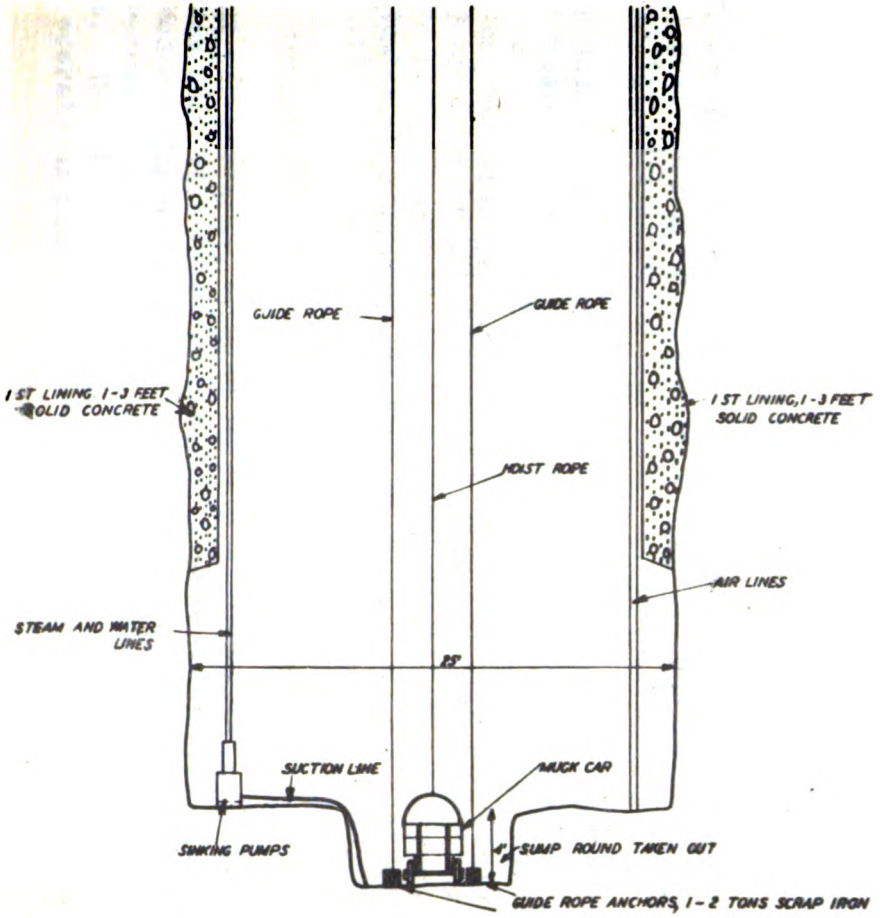

Figure 5.- Cross section of shaft during sinking

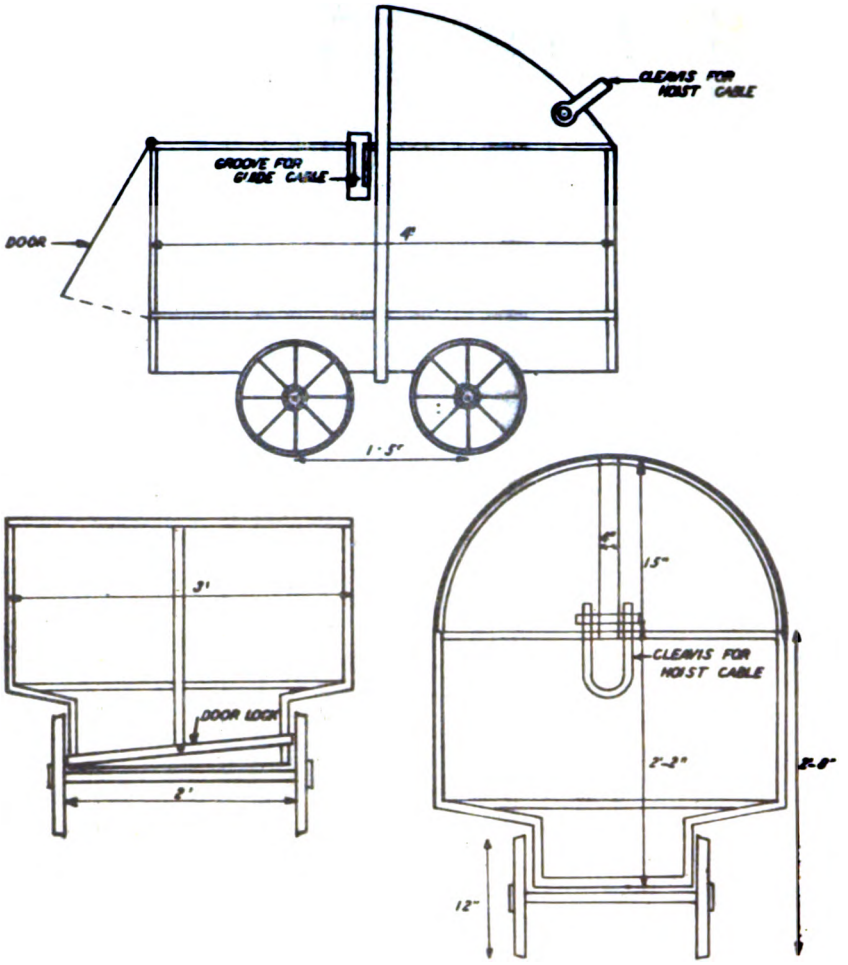

Figure 6.- Detail of muck car used for sinking

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Labor cost of sinking

	Number of shifts	Cost of labor	Cost per foot
Driller	182	$910.00	$5.00
Muckers	546	2,457.00	13.50
Hoist engineer	182	910.00	5.00
Fireman	182	837.20	4.60
Shift boss	182	1,274.00	7.00
Total	1,274	6,388.20	35.10

Drilling

The drilling of shotholes was performed by one man on each shift by means of air-driven jackhammers; 7/8-inch hexagon hollow drill steels 3 and 6 feet long were dressed to 1½ and 1¼ inch diamond point bits respectively. A complete round constituted 54 shot holes drilled to a depth of 4 feet. The first or center round consisted of 16 shot holes and the second and third rounds of 19 shot holes, placed as shown in Figure 4. Drilling was performed in one section while mucking was being carried on in another and was a continuous operation.

Blasting

All shots were fired electrically from the surface, a special shot-firing cable being used for this purpose.

The explosive used was 40 per cent gelatin, the cartridges being 8 inches long and 1-1/4 inches in diameter, two sticks or 1 pound being the load for each hole. Number 6 instantaneous, first delay, and second delay blasting caps were used, exploding at three-second intervals. The shot holes were tamped to the collar with noncombustible material by means of wooden tamping sticks.

The following table shows the pounds of explosive, number of blasting caps used, total cost, pounds of explosive, number of caps per foot of advance, and cost per foot for explosives.

Pounds of explosive used	2,457
Number of blasting caps used	2,457
Cost per pound explosives	19¢
Cost per blasting cap	7.5¢
Total cost of explosives	$651.10
Pounds of explosive used per foot of advance	13.43
Number of caps used per foot of advance	13.43
Cost of explosive per foot of advance	$3.5579

Mucking

Mucking was performed by hand loading by a crew of three men on each shift. An average pull of 4 feet was blasted by each round of shots, and nearly a round was mucked out during each shift, making a complete round in the shaft, or 4 feet of advance, in 4 shifts. Usually it took the fourth shift to square the three rounds. This included operating and moving the pump, steam, and water lines, that the operations might be carried on efficiently and comfortably.

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Hoisting

A temporary timber headframe extending 40 feet above the collar of the shaft was constructed to insure height for dumping facilities and to support the sheave wheel. For hoisting men and muck, a 160-hp. second motion loose-drum steam hoist, operating at 100-pounds pressure, was installed, to which was attached a 1-inch steel cable. Steel cars of special construction were used for hoisting in place of the regular sinking bucket. The car was suspended from the cable by a three-point suspension and was so constructed that when hoisting, the rope was in the center, and when it was run out on the dump the rope was at the bottom. Figure 6 shows the details of construction of the car.

To avoid turning of the hoisting car in the shaft, two steel guide cables 1-1/8 inches in diameter were installed and run in special grooves placed on the car. These cables were paid out from drums located in the head frame as shown in Figure 7. As sinking proceeded, they were held steady at the face of the sinking by weights consisting of 1 to 2 tons of scrap iron (fig. 4).

Lining

The shaft was lined with 1 to 3 feet of solid reinforced concrete as sinking proceeded downward in 5-foot sections. No back filling or timber was used in this shaft, and the lining was kept within 5 feet of the face. This method served two purposes: first, it eliminated the necessity of using timber for the support of the sides, and second, it kept under control the inflow of water from the strata.

After passing the coal bed, the second lining and curtain walls of 12 to 13 inch thick reinforced concrete were placed, starting at the bottom and advancing upward to the collar. In the two linings there were placed 1,584 yards of concrete containing 22 railroad cars of cement, 6 cars of reinforcing steel, and 72 cars of sand and gravel. Cement was purchased in carload lots containing about 450 sacks and was delivered as purchased to the town of Salina, which was the nearest point on the railroad. From this point it was hauled to the mine, a distance of 18 miles, by motor truck or teams. The cost of the cement at the mine was $1.38 per hundred pounds.

Sand and gravel was delivered to the mine by motor truck and teams under contract at $1.25 per cubic yard; 1320 cubic yards of this material was used in the shaft linings. The concrete was mixed at the shaft collar and conducted into the forms through flexible steel pipes 10 inches in diameter.

The work of placing the concrete linings was carried on in 8-hour shifts. An average of two shifts was consumed in building forms and one shift in pouring the concrete. All the concrete work was completed in 182 shifts.

The following tables show the number of shifts and man-hours worked, and the labor cost of concrete linings per foot of sinking.

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Men employed and shifts worked per foot of sinking

	Number	Shifts worked	Man-hours	Man-hours consumed per foot of sinking	Cubic yards of concrete placed	Man-hours per cubic yard of concrete
Shift boss	1	182	1,456	8	1,584	.9192
Mixer attendant	1	182	1,456	8	1,584	.9192
Laborers	3	546	4,368	24	1,584	2.7575
Head carpenter	1	182	1,456	8	1,584	.9192
Form builders	2	364	2,912	16	1,584	1.8384
Total	8	1,456	11,648	64	1,584	7.3535

Labor cost per foot of lining and per cubic yard of concrete

	Number of shifts	Labor cost	Cost per foot of lining	Cubic yards of concrete	Labor cost per cubic yard of concrete
Shift boss	182	$1,274	$ 7.00	1,584	.8043
Mixer attendant	182	819	4.50	1,584	.5171
Laborers	546	2,457	13.50	1,584	1.5511
Head carpenter	182	1,456	8.00	1,584	.9192
Form builders	364	1,638	9.00	1,584	1.0341
Total	1,456	$7,644	$42.00	1,584	4.8258

Disposal of Muck

When the car loaded with muck was hoisted, it was run out on a trestle extending 60 feet from the shaft (fig. 8) without detaching the hoisting cable, and dumped automatically by the hoistman. From this place the material was deposited in various depressions by men with a team and scraper. This labor was performed in 274 shifts at a total cost of $1,644.

Gas

No gas pressure was encountered during the sinking of this shaft.

Water

No water was encountered until the sinking had advanced 60 feet down, after which it was a problem of major importance. However, the water was kept under control by sealing, which was accomplished by the first lining and by forcing raw cement, at 150 to 200 pounds air pressure, through drill holes placed across the water slips.

At present approximately 100 gallons of water per minute are being made, which are removed by two No. 7 vertical plunger Cameron steam sinking pumps, operating at 100 pounds pressure.

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In order to insure the water supply for power generating and town purposes independent of the river water, 16 control pipes 1½ inches in diameter were installed in the shaft lining and protrude just enough to allow capping. This feature will be a decided advantage during the flood water season because it will eliminate the necessity of settling tanks to insure a clean water supply for power, feed, and culinary purposes.

Ventilation

Ventilation during sinking was supplied by a Buffalo blower fan belt driven by a steam engine, delivering the fresh air to the face through Ventube, 12 inches in diameter.

Supervision

Inspection and safety of the workmen were at all times under the constant supervision of an experienced shift boss while work was being carried on. He had no other duties than to direct the men and care for their safety. The excellence of this arrangement is reflected by the fact that during the sinking and lining of this shaft, no injury occurred that involved the loss of one day's time.

Wage Scale

	Per shift
Head carpenter	$8.00
Shift boss	7.00
Teamster (man and team)	6.00
Drillers	5.00
Hoist engineer	5.00
Fireman	4.60
Muckers	4.50
Form builders	4.50
Laborers	4.50

All employees were under the direct control of the shift boss and superintendent. No contract or bonus system of pay was used. Eight hours constituted a shift, and no particular task was assigned as a shift's work.

Cost Data

Cost of sinking and lining a shaft 17 by 25 by 182 feet deep divided into three compartments

	Cost of labor	Cost of material	Total cost	Cost per foot
Drilling and blasting	$ 910	$1,015.10	$1,925.10	$10.57+
Mucking	2,457	364.00	2,821.00	15.50
Haulage	910	182.00	1,092.00	6.00
Lining	6,370	21,385.00	27,755.00	152.50
Disposal of material	1,644	100.00	1,744.00	9.58
Supervision	3,822	250.00	4,072.00	22.38
Total	$16,113	$23,296.10	39,409.10	$216.53

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The cost data contained in the above table includes only the actual cost of sinking, lining, and partitioning the shaft with reinforced concrete.

The cost of preparing the surface for sinking, mining coal from the resin coal bed for making steam power, the buildings necessary for office, warehouse, shop, and housing equipment, and the necessary sinking and hoisting machinery, are not included in these data, due to the fact that these items are permanent fixtures and will be used in the regular operation of mining coal.

The proportion of the cost of these items that may be charged to the shaft-sinking operation is approximately $38 per foot of depth.

Through the sinking of this shaft and the completion of the Salina branch of the Denver, Rio Grande and Western Railroad one of Utah's most valuable coal districts will be opened, which will prove to be of economic value in the development of the Sevier and Sanpete Valleys.

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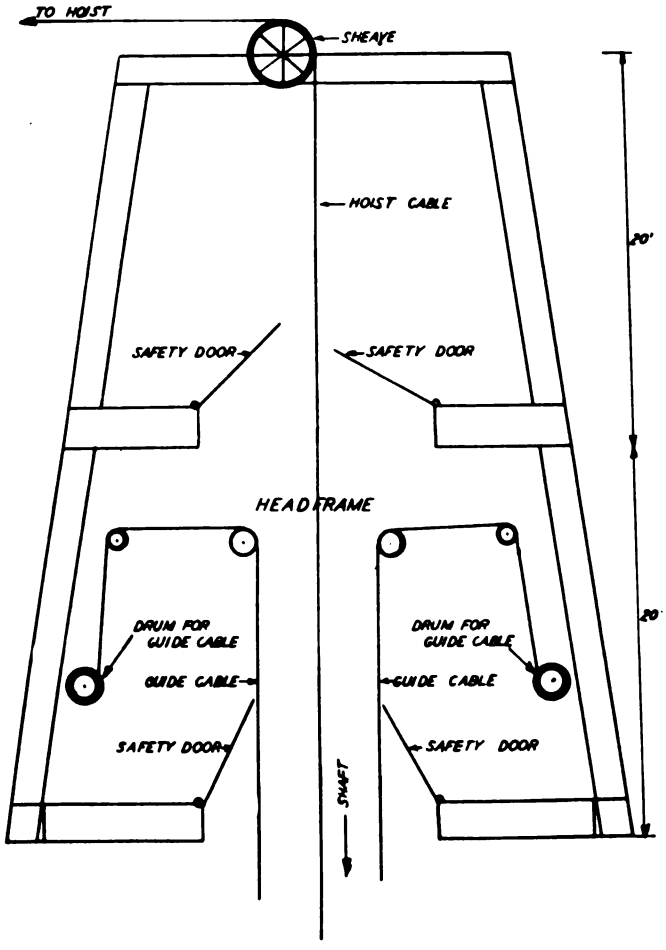

Figure 7.- Position of guide drums and safety doors in headframe

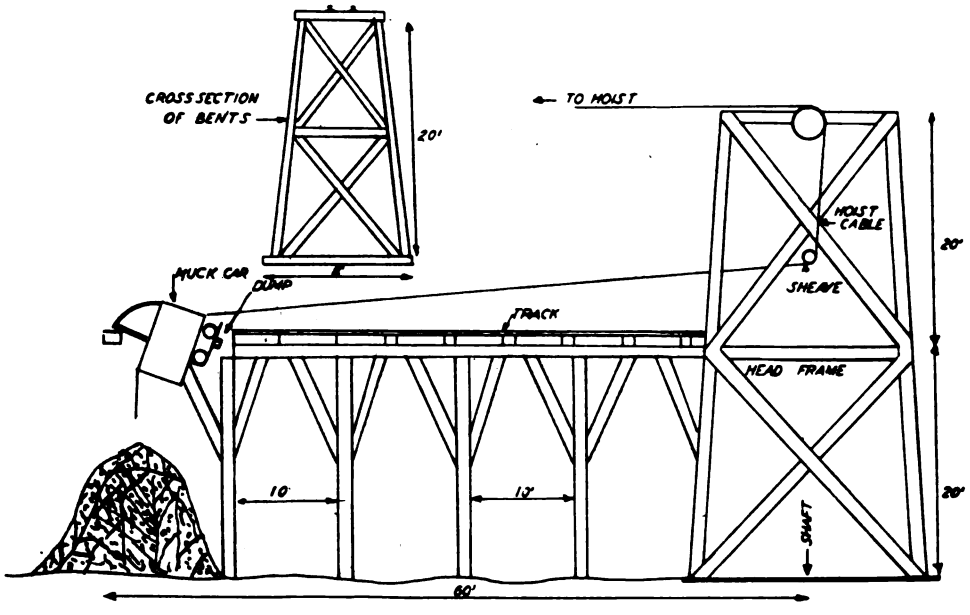

Figure 8.- Arrangement for muck dumping

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